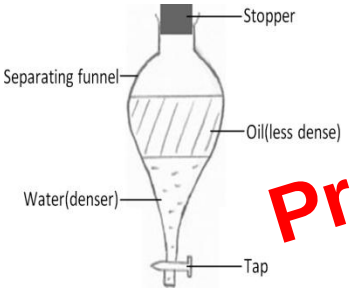
TABLE OF CONTENT

- Seawater is pumped under great pressure into a closed container onto a membrane forcing water particles but salt particles to pass through. Some salt particles may still pass through.

Use of Separating Funnel

Separating Funnel is used to separate immiscible liquids



- two liquids insoluble to each other will create two layers of overlying liquids of each type. To separate, take the stopper off and turn the tap on to run the denser liquid at the bottom off the funnel and leave the less dense liquid in the funnel by turning the tap off and reset the stopper at its original position.

Chromatography

Chromatography – a method of separating and identifying mixtures.

The need for Chromatography

- Separates and identify mixtures of coloured substances in dyes
- Separates substances in urine, drugs & blood for medicinal uses
- To find out whether athletes have been using banned drugs

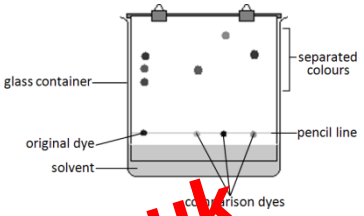
Separating Mixtures of Coloured Substances

Obtain a dye sample then put a drop of the sample on a pencil line drawn on the filter paper then dip the paper into a solvent with the level below the spot. The dye will dissolve in solvent and travel up the paper at different speed. Hence they are separated.

Identifying Mixturees of Coloured Substances

In the diagram on the right, drop of sample dye is placed on pencil line. The result shows that:

- The sample dye is made of 3 colours.



- 2 comparison dyes are of one of the compositions of the original dye as the spots are of same colour and distance.
- a comparison dye isn't part of sample.

Separating and Identifying Mixtures of Colourless Substances

To do this a locating agent is to be sprayed on filter paper.

Locating Agent – a substance that reacts with substances (e.g. sugars) on paper to procuce a coloured product.

R_f Values

To identify unknown dye in the diagram at the very top:

R_f value = $\frac{x}{y}$

Where x = distance moved by the substance and;

y = distance moved by the solvent

Checking the Purity of Substances

- Pure substances have FIXED MELTING AND BOILING POINTS.

❖ Pure water boils at 100°C and melts at 0°C.

- Impure substances have NO FIXED MELTING AND BOILING POINTS. They melt and boil at a RANGE OF TEMPERATURES

❖ e.g. starts boil at 70°C, completes boil at 78°C

➢ Also, it can VARY melting and boiling points of pure substances.

❖ e.g. pure water boil at 100°C, but with salt is at 102°C

1.3 Identification of Ions and Gases

Refer to Insert 1. Everything lies there.

END OF CHAPTER 1

CHAPTER 4 – ELECTROLYSIS

4.1 Introductory Electrolysis

Electrolysis is the decomposition of compound using electricity

Electrolyte is an ionic compound which conducts electric current in molten or aqueous solution, being decomposed in the process.

Electrode is a rod or plate where electricity enters or leaves electrolyte during electrolysis. Reactions occur at electrodes.

Discharge is the removal of elctrons from negative ions to form atoms or the gain of electrons of positive ions to become atoms.

Anode is positive electrode connected to positive terminal of d.c. source. Oxidation occurs here. **Anode** loses negative charge as electrons flow towards the battery, leaving anode positively charged. This causes anion to discharge its electrons here to replace lost electrons and also, negativecharge are attracted to positive charge.

Cathode is negative electrode connected to negative terminal of d.c. source. Reduction occurs here. **Cathode** gains negative charge as electrons flow from the battery towards the cathode, making cathode negatively charged. This causes cation to be attracted and gains electrons to be an atom.

Anion is negative ion. It's attracted to anode.

Cation is positive ion. It's attracted to cathode.

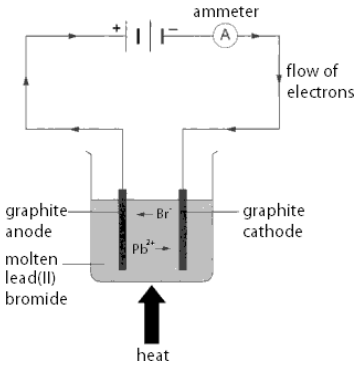
4.2 Electrolysis of Molten Compounds

Molten/aqueous ionic compounds conduct electricity because **ions free to move**. In solid state, these ions are **held in fixed position** within the crystal lattice. Hence solid ionic compounds ***do not conduct electricity***.

When **molten binary compound** is electrolysed, **metal** is formed on **cathode** while **non-metal** is formed on **anode**.

Electrolysis of Molten $PbBr_2$

To make molten lead(II) bromide, $PbBr_2$, we strongly heat the solid until it melts. To electrolyse it, pass current through the molten $PbBr_2$.



Ions Present

Pb^{2+} and Br^-

Reaction at Anode

Br^- loses electrons at anode to become Br atoms. Br atoms created form bond together to make Br_2 gas.

$$2Br^-(aq) \rightarrow Br_2(g) + 2e^-$$

Reaction at Cathode

Pb^{2+} gains electrons at cathode to become Pb atoms becoming liquid lead (II).

$$Pb^{2+}(aq) + 2e^- \rightarrow Pb(l)$$

Overall Equation

$$PbBr_2(l) \rightarrow Pb(l) + Br_2(g)$$

Below are other compounds that can be electrolysed. The theory's same as $PbBr_2$.

Molten electrolyte	Cathode product	Anode product
Calcium chloride ($CaCl_2$)	Calcium, Ca	Chlorine, Cl_2
Sodium chloride ($NaCl$)	Sodium, Na	Chlorine, Cl_2
Aluminium(III) oxide (Al_2O_3)	Aluminium, Al	Oxygen, O_2
Sodium Iodide (NaI)	Sodium, Na	Iodine, I_2

4.3 Electrolysis of Aqueous Solution

Aqueous solutions contain additional H^+ and OH^- ions of water, totalling 4 ions in the solution – 2 from electrolyte, 2 from water. Only 2 of these are discharged.

Electrolysis of aqueous solutions use the theory of **selective discharge**.

$4H^+$ and $4OH^+$ ions, however, combine to form $4H_2O$ molecules. Hence:

$$4H_2O(l) \rightarrow 2H_2(g) + O_2(g) + 2H_2O(l)$$

H_2O molecules are formed on both sides. Therefore, they cancel the coefficients:

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$$

Since only water is electrolysed, the sulfuric acid now only becomes concentrated.

4.4 Electrolysis Using Different Types of Electrodes

Inert Electrodes are electrodes which do not react with electrolyte or products during electrolysis. Examples are platinum and graphite.

Active Electrodes are electrodes which react with products of electrolysis, affecting the course of electrolysis. Example is copper.

Electrolysis of $CuSO_4$ Using Inert Electrodes(e.g. carbon)

Ions Present

Cu^{2+}, H^+, OH^- and SO_4^{2-}

Reaction at Anode

OH^- loses electrons at anode to become O_2 and H_2O.

$$4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$$

Reaction at Cathode

Cu^{2+} gains electrons at cathode to become Cu atoms becoming liquid copper. Hydrogen ions are not discharged because copper is easier to discharge.

$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$

Overall Equation

Both equations must be balanced first. The cathode equation is short 2 electrons. Hence, we should first even them by multiplying cathode equation by 2.

$$(Cu^{2+}(aq) + 2e^- \rightarrow Cu(s))x2$$
$$= 2Cu^{2+}(aq) + 4e^- \rightarrow 2Cu(s)$$

Now we can combine the equations, forming:

$$2Cu(OH)_2(aq) \rightarrow 2Cu(s) + O_2(g) + 2H_2O(l)$$

Since copper ions in solution are used up, the blue colour fades. Hydrogen and sulphate ions left forms sulphuric acid.

Electrolysis of $CuSO_4$ Using Active Electrodes(e.g. copper)

Ions Present

Cu^{2+}, H^+, OH^- and SO_4^{2-}

Reaction at Anode

Both SO_4^{2-} and OH^- gets attracted here but not discharged. Instead, the copper anode discharged by losing electrons to form Cu^{2+}. So, the electrode size decreases.

$$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$$

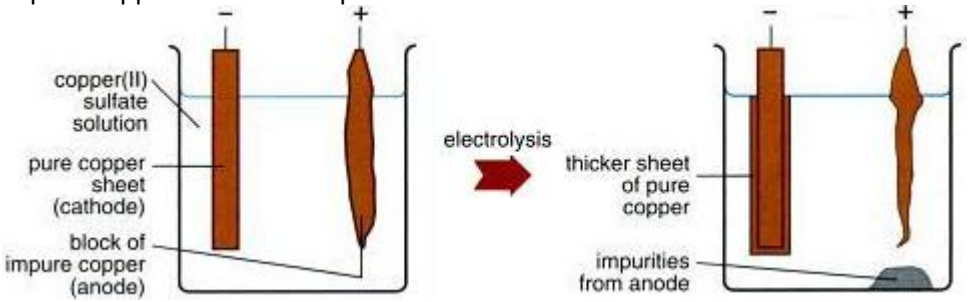
Reaction at Cathode

Cu^{2+} produced from anode gains electrons at cathode to become Cu atoms becoming copper. Hence, the copper is deposited here and the electrode grows.

$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$

Overall Change

There is no change in solution contents as for every lost of Cu^{2+} ions at cathode is replaced by Cu^{2+} ions released by dissolving anode. Only the cathode increases size by gaining copper and anode decreases size by losing copper. We can use this method to create pure copper on cathode by using pure copper on cathode and impure copper on anode. Impurities of anode falls under it.



4.5 Electroplating

Electroplating is coating an object with thin layer of metal by electrolysis. This makes the object protected and more attractive.

NaCl: (+1) + (-1) = 0

K_2O: (+1) x 2 + (-2) = 0

Al_2O_3: (+3) x 2 + (+2) x 3 = 0

- Sum of oxidation states of elements in an ion is equal to charge on the ion, e.g.

OH^-: (-2) + (+1) = -1

Examples:

Work out the oxidation states of the underlined elements in these compounds:

(a) $\underline{C}O_2$

(oxidation state of C) + (-2) x 2 = 0

(oxidation state of C) + (-4) = 0

∴ Oxidation state of C = +4

(b) $K\underline{Mn}O_4$

(+1) + (oxidation state of Mn) + (-2) x 4 = 0

(oxidation state of Mn) + (+1) + (-8) = 0

(oxidation state of Mn) + (-7) =0

∴ Oxidation state of Mn = +7

(c) $\underline{Fe}(NO_3)_2$

(oxidation state of Fe) + (-1) x 2 = 0

(oxidation state of Fe) + (-2) = 0

∴ Oxidation state of Fe = +2

Note: Transition metals and some common elements may have different oxidation states in different compounds.

Examples of elements with variable oxidation states

Oxidation state	-2	-1	0	+1	+2	+3	+4	+5	+6	+7
Manganese			Mn		$MnCl_2$		MnO_2			$KMnO_4$
Chromium			Cr		$CrCl_2$	$CrCl_3$			$K_2Cr_2O_7$	
Iron			Fe		$FeCl_2$	$FeCl_3$				
Sulphur	FeS		S				SO_2		H_2SO_4	
Carbon			C		CO		$CaCO_3$			

Some compounds with possible variable oxidation states have roman numeral as a guide about their oxidation state, e.g.

- Iron(II) chloride has formula $FeCl_2$ and iron oxidation state +2
- Potassium(VI) dichromate has formula $K_2Cr_2O_7$ and potassium oxidation state +6
- Manganese(IV) oxide has formula MnO_2 and manganese oxidation state +4

Oxidation is the *increase of oxidation state* by a substance

Reduction is the *decrease of oxidation state* by a substance

Note:
- Losing electrons means gain in oxidation state
- Gaining electrons means loss in oxidation state

Examples:

Metals with acids

$$Cu(s) + HCl(aq) \rightarrow CuCl_2(aq) + H_2(g)$$

Cu is oxidized as it gains oxidation state from 0 to +2. Cu is reducing agent

H^+ ions in HCl reduced as it loses oxidation state from +1 to 0. H^+ ions are oxidising agent

Halide (Halogen) Displacement Reactions

$$Cl_2(aq) + 2KI(aq) \rightarrow 2KCl(aq) + I_2(aq)$$

I^- ions in KI oxidized as it gains oxidation state from -1 to 0. I^- ions is reducing agent

Cl_2 is reduced as it loses oxidation state from 0 to -1. Cl_2 is oxidizing agent

Test for Oxidising/Reducing Agents

Oxidizing agents		
Name of compound	**Formula**	**Applications**
Potassium dichromate(VI)	$K_2Cr_2O_7$	Test for reducing agent; orange $K_2Cr_2O_7$ reduces to green Cr^{3+} ions
Potassium manganate(VII)	$KMnO_4$	Test for reducing agent; purple $KMnO_4$ reduces to colourless Mn^{2+} ions
Chlorine	Cl_2	Oxidizes Br^- to Br_2 and I^- to I_2; green-yellow Cl_2 reduces to colourless Cl^- ions

5. Iron ore contains many impurities (silicon, sulphur, phosphorus, etc.) Sand, SiO_2, reacts with calcium oxide to produce slag (calcium silicate). Slag runs down to the bottom of the furnace, floating on top of molten iron

$$CaO_{(s)} + SiO_{(s)} \rightarrow CaSiO_{3(l)}$$

6. Molten iron & slag tapped off separately in furnace. Slag is for road construction.

7. Referring to equation, not all iron(III) oxide reacted with carbon, only small amount

$$Fe_2O_3(s) + 3C(s) \rightarrow 2Fe(l) + 3CO_3(g)$$

Steel

Iron made from blast furnace is not good as:

- it contains impurities which makes it brittle (can break easily)
- it cannot be bent or stretched

Most iron is converted into steel which is an alloy of iron and carbon with small amounts of other elements. Advantages of steel:

- it is strong and tough
- it can be bent and stretched without shattering

Making Steel:

- Impurities of iron is removed by blowing oxygen into molten iron to change the impurities into oxides. They are then combined with CaO and removed as slag.
- Carbon and other metals are added in certain amount to make steel.

Different Types of Steel:

- Mild steel – is a low carbon steel with 0.25% carbon
  - It is strong and quite malleable. It is used for car bodies, ships, railway lines and steel rods to reinforce concrete
- Hard steel – is a high-carbon steel with about 1% carbon
  - It is harder than mild steel and less malleable. It is used to make tools
- Stainless steel – is iron with large amounts of chromium and nickel
  - It is hard, shiny and doesn't rust. It is used to make cutleries, medical instrument and pipes in chemical industries.

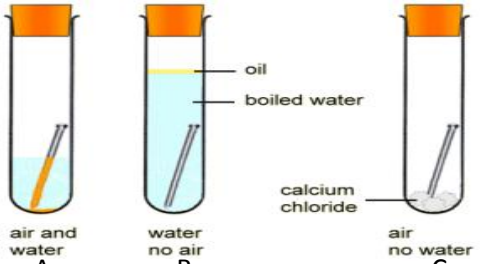
Rusting

Rusting – corrosion of iron and steel

Rust – brown solid product formed during rusting

Rust is hydrated iron(III) oxide $Fe_2O_3 \cdot xH_2O$ where water molecules varies.

Conditions for Rusting



Tubes

After a few days, only nail in tube A rust. This shows that air and water is needed for rust. In boiled water, the nail doesn't rust in B as boiled water removes dissolved air while in C, Ca*Cl* keeps air dry so there's no water.

Other factor → dissolved salt

Preventing Rusting

- Surface protection
- Sacrificial protection
- Use of stainless steel

Surface Protection – covers metal with a layer of substance

1) **Paint**
2) **Grease or oil** (also help to lubricate)
3) **Plastic**
4) **Metal Plating** – covering metal with thin layer of another metal (e.g. tin, chromium, silver)

Advantage – These methods are cheap (except metal plating)

Disadvantage – If the layer is broken, air and water an reach metal to rust

What hazard it brings?

Eutrophication, lung damage, acid rain

How to prevent this?

- Install catalytic converters in cars
- Design car engines which run at lower temperatures

Chemistry around us: ACID RAIN

Acid rain is formed by 2 main constituents – SO_2 and NO_2

Sulphur dioxide/nitrogen dioxide both react with oxygen and water to form sulphuric acid/nitric acid. This is called *hydrolysis*

$$2SO_2(g) + O_2(g) + H_2O(l) \rightarrow 2H_2SO_4(aq)$$

$$4NO_2(g) + O_2(g) + 2H_2O(l) \rightarrow 4HNO_3(aq)$$

Effects of Acid Rain

- The acid corrodes buildings, $CaCO_3$ materials and metal statues.
- Acid rain damages trees
- Acid rain increases acidity of soil, making soil unsuitable for plant growth
- Fish cannot survive in acidic water
- Aggravates respiratory ailments such as bronchitis and asthma

Tackling Acid Rain

- Remove sulphur dioxide from flue gases by *desulphurization*
- Add $Ca(OH)_2$ to soil to neutralize acid from acid rain
- Burn fuels with less sulphur

Desulphurization

It is the removal of sulphur dioxide from flue (waste) gases. The product is CO_2, which is non-polluting gas, and calcium sulphite.

$$CaCO_3(s) + SO_2(g) \rightarrow CaSO_3(s) + CO_2(g)$$

To increase profit, calcium sulphite further oxidized to produced gypsum to be sold

$$2CaSO_3(s) + O_2(g) + 4H_2O(l) \rightarrow CaSO_4.2H_2O(g)$$

4. Methane

Where it comes from?

Decomposition of vegetable matter; rice field; cattle ranching; natural gas; mines

What hazard it brings?

It is highly flammable, greenhouse gas

How to prevent this?

- Cattle and other ruminant animals should be given improved diet
- Animal manure and rotting vegetation can be used as biomass fuel

5. Unburnt hydrocarbons

Where it comes from?

Internal combustion engunes; incomplete combustion of hydrocarbons

What hazard it brings?

Carcinogenic, forms photochemical smog

How to prevent this?

- Install catalytic converters in cars
- Reduce number of cars on road
- Create efficient engines in cars to ensure complete hydrocarbon combustion

6. Ozone

Where it comes from?

It is an allotrope (two/three different forms of a pure element) of oxygen having structural formula O_3 having characteristic odour. It's created by reaction of nitrogen oxides with volatile organic compounds in presence of UV radiation.

What hazard it brings?

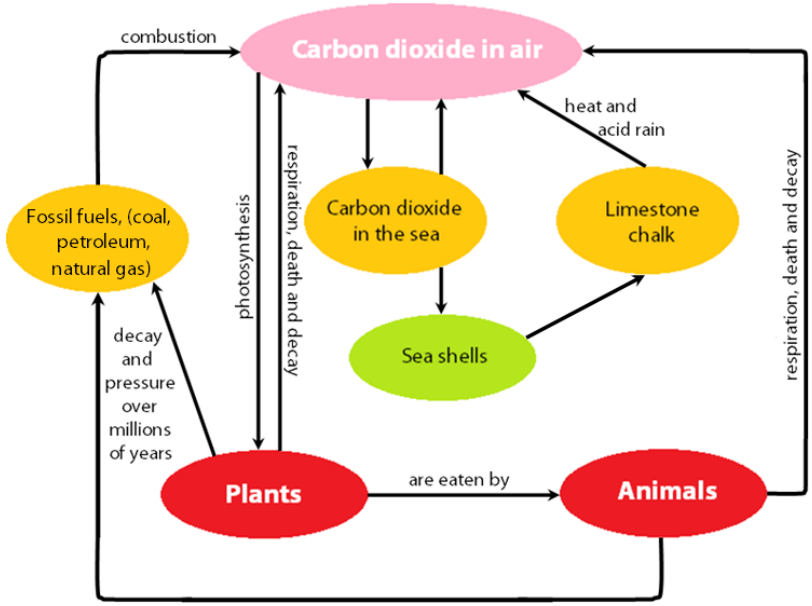
- It reacts with unburnt hydrocarbons to form photochemical smog that causes headache, eye, nose and throat irritation.

TACKLING GLOBAL WARMING

- Reduce the use of fossil fuels
- Use alternative forms of energy such as wind, tidal and hydroelectric power
- Use more electric vehicles
- Reduce number of cars on road
- Create efficient engines in cars to ensure complete hydrocarbon combustion

Chemistry around us: CARBON CYCLE

0.03% of the atmosphere is carbon dioxide and this is kept constant by the process *carbon cycle*. ***Carbon cycle*** is the removal of carbon dioxide by plants by photosynthesis and the replacement of these carbon molecules by combustion, respiration and natural processes. In the past the rate of absorption of carbon dioxide balance the rate of production of carbon dioxide. Man upset this balance.



WHAT LIVING THINGS DID

Plants:

Plants use carbon dioxide from atmosphere, sunlight and chlorophyll for photosynthesis of sugars. Some carbon is used up in plants for growth and development, while some others are released to atmosphere during respiration. When plants die & decomposed by microorganisms, CO_2 released to atmosphere.

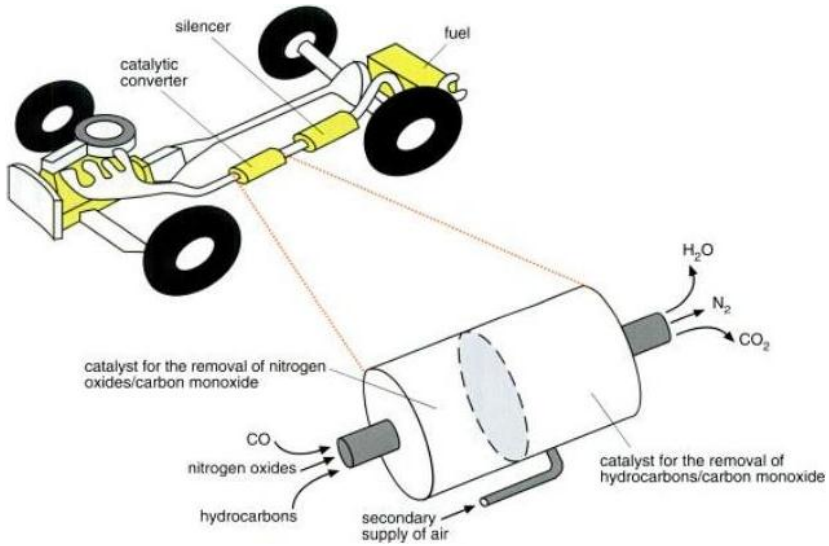
Animals:

When herbivores and omnivores eat plants, they gain carbon from them to grow and develop. Carnivores eating these animals also gain the carbon. When animals respire, they release carbon dioxide. When they die and decay due to microorganism, they release carbon dioxide which is later taken in by plants.

WHAT NON-LIVING THINGS DID

Carbon monoxide and carbon dioxide are released from electric power plants, exhaust fumes and factory emissions. Man burns fossil fuels, which needs millions of years to form, that takes in oxygen and releases carbon dioxide. This makes man depleting natural resource as they use them rapidly than the time needed to reform, damages natural environment and upsetting balance of carbon cycle.

Balancing Chemicals in Nature: CATALYTIC CONVERTERS



First, nitrogen oxides reacts with carbon monoxide as they pass a platinum catalyst.

$$2NO(g) + CO(g) \rightarrow N_2(g) + 2CO_2(g)$$

In second half of converter, unburnt hydrocarbons (e.g. octane, C_8H_{18}) reacts with more air to form CO_2 and H_2O.

$$2C_8H_{18}(g) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$$

CO_2, H_2O and N_2 are all non-pollutants. These reactions are all redox.

7. Lead compounds

Where it comes from?

- Combustion of leaded petrol in car engines

What hazard it brings?

- Causes lead poisoning which leads to brain damage.

10.2 Water

Water is most available liquid on Earth covering 70% of the planet surface.

We use water at home for: drinking, cooking, washing and bathing

While in industries, we use as: heat exchanger, raw material for food and drinks, as a solvent, cleaning and purification, irrigation, dyeing and bleaching process.

Inside that Water

Naturally Occuring Substances

- Mineral salts – aluminium, calcium, potassium, etc.
- Dissolved oxygen given out by aquatic animals by photosynthesis
- Organic matter (living/dead plants, animals, microorganisms)

Pollutants

- Metal compounds such as cadmium, iron, manganese, etc. from waste discharge
- Phosphates from fertilizers, detergents or sewage treatment plants
- Nitrates from fertilizers or sewage treatment plants
- Sewage from sewage treatment plants or septic systems
- Harmful microbes from sewage treatment plants, septic systems, naturally occuring in water or growing in abundance due to pollution
- Acid from industrial discharges
- Oil spills from oil tankers

Important or Silent Killer?

Beneficial Stuff

Mineral salts

- Needed for basic functions of human body such as bone growth, fluid regulation, normalize nerve and muscle functionality, metabolism control, growth, etc.
- Needed for growth of aquatic plants to make food and produce oxygen for aquatic organisms.

Dissolved oxygen

- Needed for respiration and growth of aquatic life. Water without O_2 is stagnant.

Organic matter

- Needed for growth of aquatic organisms

Harmful Stuff

Acid

- Kills aquatic organisms and plants
- Makes water acidic and corrosive – unsafe to drink

Nitrates

- Causes eutrophication which deprives marine organisms of oxygen
- Nitrate ions may cause breathlessness or kill babies when consumed

Phosphates

- Can cause eutrophication as it encourages the growth of algae, hence killing aquatic organisms when they die and takes away oxygen

Heavy metal ions

- These are carcinogenics that can cause skin cancer, liver cancer, lung cancer, etc.

Sewage

- Contains pathogens which when consumed carries diseases such as diarrhoea.

Oil

- Traps bird's feathers and kills them eventually
- Depletes oxygen as air cannot mix with water to provide sufficient oxygen

Reactions of Alkenes

Combustion

Burns in air to form carbon dioxide and water

Example: Ethene burns in air. Write the balanced equation for the reaction

$$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O\ (l)$$

Incomplete combustion forms soot and CO. It's produced more than alkane.

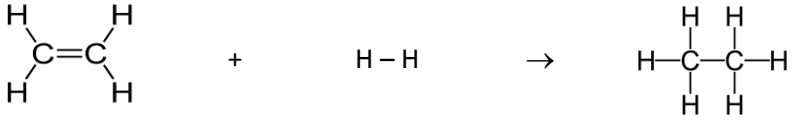
Addition Reaction

Is the reaction of 2 or more molecules to form a single product

- *Addition of hydrogen*

Alkenes react with hydrogen to form alkanes, called **hydrogenation**. Must use nickel as catalyst and heat.

$C_2H_4(g)$ + $H_2(g)$ → $C_2H_6(g)$



<u>*Nomenclature*</u>

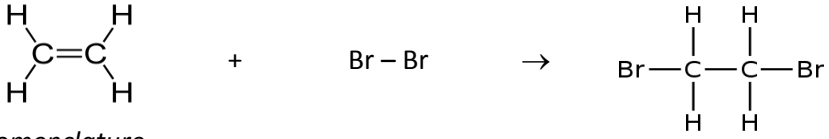
Product's an ALKANE with name according to number of carbon atoms it contain.

- *Addition of bromine*

Bromine adds to C = C double bond of alkane molecules. Phosphoric acid (H_3PO_4), high temperature of 300°C and 60-70 atm pressure are needed as catalyst.

Eg: ethene to 1,2 – dibromoethene

$C_2H_4(g)$ + $Br_2(g)$ → $C_2H_4Br_2(l)$



<u>*Nomenclature*</u>

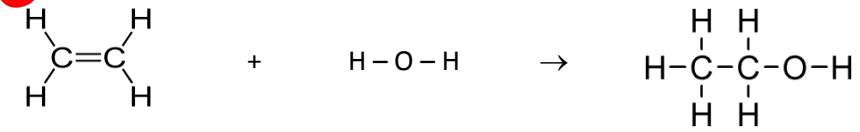
(*n*) + (bromo) + (alkene name), where *n* is the number of bromine atoms.

E.g. Above, Ethene reacts with 2 bromine atoms producing DI(2)BROMO(Bromine) ETHENE(alkene name). Hence we call the product DIBROMOETHENE.

- *Addition of water*

Alkene reacts with water, in the form of steam, to produce alcohol. Alkene + steam is passed over phosphoric acid (H_3PO_4) catalyst and temperature of 300°C. H_2O molecule adds to C = C bonds to form alcohol.

$C_2H_4(g)$ + $H_2O(g)$ → C_2H_5OH or $CH_3CH_2OH\ (l)$



<u>*Nomenclature*</u>

(alkene name) + (-ol)

E.g. in above, the alkene ethane (C_2H_4) reacts with steam to form *ETHANOL* (alkene name – ETHAN + OL group of alcohol)

- *Polymerization*

The joining of several identical alkene molecules to form a big molecule

Eg: Ethene → poly(ethene)

Testing for Unsaturated Compounds

Mix bromine solution with alkene (for liquid alkenes – shake). Reddish-brown colour of bromine disappears. This shows that the compound is an alkene.

Characteristics of a Homologous Series

- All members of homologous series have same general formula
- Formula of each member differs by $–CH_2$ group
- Physical properties changes gradually in the increase of carbon atoms
- The members have similar chemical properties

Foods and Unsaturated Compounds

The Manufacture of Margarine

Polyunsaturated food – food containing C=C bond in their molecules

Eg: Vegetable oil

INSERT I

Tests for anions

anion	*test*	*test result*
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produced
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
iodide (I^-) [in solution]	acidify with dilute nitric acid, then add aqueous lead(II) nitrate	yellow ppt.
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide then aluminium foil; warm carefully	ammonia produced
sulfate (SO_4^{2-}) [in solution]	acidify with dilute nitric acid then add aqueous barium nitrate	white ppt.

Tests for aqueous cations

cation	*effect of aqueous sodium hydroxide*	*effect of aqueous ammonia*
aluminium (Al^{3+})	white ppt., soluble in excess giving a colourless solution	white ppt., insoluble in excess
ammonium (NH_4^+)	ammonia produced on warming	-
calcium (Ca^{2+})	white ppt., insoluble in excess	no ppt. or very slight white ppt.
copper(II) (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess giving a dark blue solution
iron(II) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt., soluble in excess giving a colourless solution	white ppt., soluble in excess giving a colourless solution

Tests for gases

gas	*test and test result*
ammonia (NH_3)	turns damp red litmus paper blue
carbon dioxide (CO_2)	turns limewater milky
chlorine (Cl_2)	bleaches damp litmus paper
hydrogen (H_2)	"pops" with a lighted splint
oxygen (O_2)	relights a glowing splint
sulfur dioxide (SO_2)	turns acidified aqueous potassium dichromate(VI) from orange to green
water vapour (H_2O)	turns blue cobalt(II) chloride paper pink